ISSN (print): 1698-6180. ISSN (online): 1886-7995
www.ucm.es/info/estratig/journal.htm

Journal of Iberian Geology 36 (2) 2010: 175-180

Journal of Iberian Geology
AN INTERNATIONAL PUBLICATION OF EARTH SCIENCES

First report of a Late Jurassic lizard-like footprint (Asturias, Spain)

Primera cita de una huella lacertoide en el Jurásico Superior (Asturias, España)

M. Avanzini[1], L. Piñuela[2], J. C. García-Ramos[2]

[1]Museo Tridentino di Scienze Naturali, Via Calepina 14, I-38120 Trento, Italy.
avanzini@mtsn.tn.it
[2]MUJA, Museo del Jurásico de Asturias, Rasa de San Telmo, 33328, Colunga, Asturias, España; Depto. de Geología.
Universidad de Oviedo, C/Jesús Arias de Velasco, s/n, 33005 Oviedo, Asturias, Spain.
lpinuela@geol.uniovi.es

Received: 07/12/09 / Accepted: 30/06/10

Abstract

This report describes an isolated footprint preserved as a natural cast (convex hyporelief) from the Lastres Fm. (Late Jurassic) of northern Spain. The track consists of a small isolated pentadactyl ectaxonic right manus footprint. It is very asymmetric, plantigrade, with digits and palm deeply marked on the substrate. Digit IV is the longest, digits II and I are nearly equal in length and only a little shorter than III and IV. The footprint morphology is typical of a lizard – like or "lacertoid" track .The general outline of the footprint, the width to length ratio approximately equal to 1, the marked plantigrady and the substantial similarity in length of digits IV-I are coherent with a Rhynchosauroidea manual print. The global record of *Rhynchosauroides* ichnogenus shows that this specimen represents the latest occurrence of the ichnogenus. The most probable trackmaker was possibly a rhyncocephalian reptile.

Keywords: Upper Jurassic, "Lacertilian" tracks, *Rhynchosauroides*, Asturias, Spain

Resumen

Se describe una huella de mano aislada, preservada como contramolde natural (hiporrelieve convexo) de la Formación Lastres (Jurásico Superior) del N de España. La icnita, aislada, pentadáctila, ectaxónica y de pequeño tamaño, es atribuida a una mano de-

recha. Es muy asimétrica y plantígrada, con los dedos y la palma profundamente impresos en el sustrato. El dedo IV es el más largo, mientras que el II y el I son casi iguales en longitud y solamente un poco más cortos que el III y el IV. La morfología de la huella es típica de un lagarto o "lacertoide". El contorno de la huella, la relación longitud/anchura en torno a 1, la longitud similar de los dedos I-IV y el hecho de que sea claramente plantígrada son rasgos coherentes con una huella de mano de un Rhynchosauroidea. El registro global de *Rhynchosauroides* indica que el ejemplar asturiano representa la evidencia más reciente de este icnogénero. El autor de la huella fue probablemente un reptil rincocéfalo.

Palabras clave: Jurásico Superior, huellas "lacertoide", *Rhynchosauroides*, Asturias, España

1. Introduction and geological setting

A grey (creamy on the surface) medium-grained sandstone slab (37x24x10 cm) bearing a lacertoid track - among other invertebrate traces and possible reptile scratch marks - was collected from the Lastres Formation of Villaviciosa (Asturias, Northern Spain) and is now exhibited in the Museo del Jurasico de Asturias (MUJA) (Fig.1).

The Upper Jurassic (Kimmeridgian) Lastres Formation contains many vertebrate tracksites with a large variety of taxa. Most are of dinosaurs, but several sites include pterosaur, turtle and crocodilian tracks (García-Ramos *et al*., 2002; 2006; Avanzini *et al*., 2005; 2007).

The sedimentary palaeoenvironment of Lastres Formation was a fluvial-dominated deltaic system at a paleolatitude of about 33° N.

The material described here (reported for the first time by García-Ramos *et al*., 2002), consists of an isolated footprint preserved as a natural cast (convex hyporelief). The track's features are typical of "lacertoid" footprints: a pentadactyl manual print with digits increasing in length from I to IV.

Paleozoic and Mesozoic lacertoid footprints have been compared to this newly discovered track, but only *Rhynchosauroides* ichnogenus share most of the features. Although dinosaur tracks are well known in Late Jurassic, tracks of non dinosaur vertebrates are fairly rare, and no lizard-like ones have so far been reported.

2. Ichnologic description

The track consists of an isolated pentadactyl ectaxonic right manus footprint of length 25mm and width 24mm. It is very asymmetric, plantigrade, with digits and palm deeply marked on the substrate (Fig. 2).

The functional prevalence is external thus digits III and IV are the best impressed ones.

Traces of an outward slipping are preserved on the medial side of the print and on digits I-III.

The digits are straight or slightly turned inwards. Digit group I-III is nearly parallel while digit I shows a slight inward rotation. The divergence of digit group I-IV is equal to 50°. The angle between digit I and V is 105°.

Digit IV is only a little longer than digit III while digits II and I are nearly equal in length and only a little shorter than III and IV. Digits IV and III show the metacarpal-phalangeal articulation almost aligned and more distal with respect to digit I-II group. Digit V is short and stout with the base lined up with the base of digit IV. Its claw is imprinted below the first pad of digit I. All the claw marks are sub-triangular in shape with a large base and an arched pointed tip; they turn either inward (I and II) or outward (III and IV).

Digit I is slightly outward arched and shows two phalangeal pads (free digit Length – 10 mm). Digit II is slightly inward arched and shows three possible phalangeal pads (free digit Length – 10 mm). Digit III is stout, without well recognisable phalangeal pads and with a robust and arched claw on the tip (free digit Length – 11mm). Digit IV is the longest one; it is slender with a marked and pointed claw marks and shows four well recognisable and one faint phalangeal pads (free digit Length – 12 mm). Digit V is the shortest, outward rotated, with a short triangular claw on the tip (free digit Length – 7 mm).

The phalangeal formula, calculated by counting the phalangeal pads, seems to be 2, 3, ?, ?5, ?

3. Discussion

The overall footprint morphology is typical of a lizard – like or "lacertoid" track.

In the Jurassic the tracks of non - dinosaurian reptiles are scarcely documented and tracks generically attributable to lizard–like reptiles are reported only in the Lower Jurassic of the United States (Irmis, 2005; Lockley, 1991; Olsen and Rainforth, 2003; Rainforth, 1997). They were attributed to *Rhynchosauroides* and *Lacertipus* ichnogenera. Lockley and Hunt (1995) doubt the validity of *Lacertipus*, suggesting that this track can be explained as a cursorial version of *Brasilichnium* (a mammal-like reptile track). For this reason the only lizard–like ichnogenus actually accepted for the whole Jurassic would be *Rhynchosauroides*.

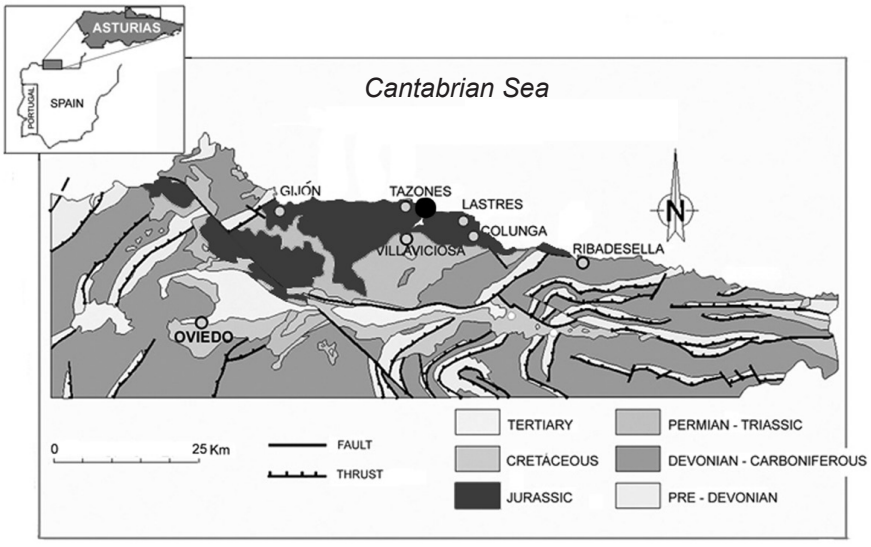

Fig. 1.- Geological sketch of the Asturias region (northern Spain). The Late Jurassic outcrop of Villaviciosa that yielded the described footprints is indicated by dot.
Fig. 1.- Esquema geológico de la región de Asturias (norte de España). El yacimiento del Jurásico Superior de Villaviciosa que ha proporcionado las huellas descritas se indica con un punto.

The ichnogenus *Rhynchosauroides* and the type-species *Rhynchosauroides rectipes* were erected in 1911 on the basis of some Lower Triassic footprints reported from the Keuper Sandstone Fm. (now Helsby Sandstone) of Runcorn, Cheshire, UK (Beasley in Maidwell, 1911).

The original diagnosis was revised by Haubold (1971), who described this ichnite as an ectaxonic track, asymmetric, from semiplantigrade to plantigrade. In Haubold's opinion, the large pace as well as the proportions between the digits (which correspond to a 2:3:4:5:3 phalangeal formula), and the great length of *pes* digit IV, which is external to the area of maximal load, are characteristic of "lacertoid" trackmakers. In typical *Rhynchosauroides* manus and pes tracks, the digits increase in length from I to IV, while digit V is much shorter than the others and is turned outwards. The pes, digitigrade, is larger and slenderer than the manus, and generally anterior to it. The digits from I to IV can be inwardly curved and the fourth is the longest. The *manus* is more internal located than the *pes*, more plantigrade, wide and has shorter digits.

All the characteristics listed above fit this newly discovered footprint well and we can infer that, the attribution to the morphofamily Rhynchosauroidea is acceptable. In particular the general outline of the footprint, the width to length ratio approximately equal to 1 (1.04), the marked plantigrady and the substantial similarity in length of digits IV-I are coherent with a Rhynchosauroidea manual footprint.

The presence of some burrows produced by bivalves (*Lockeia*), the absence of emersion signs as mud cracks, the absence of the tail impressions, and mainly there are not tracks in front and behind of this manual print, forming a trackway, would suggest a possibly subaqueously produced track (probably semi-aquatic tracks, *sensu* Silva *et al.* 2008).

Footprints of other small reptiles such as crocodiles are excluded due to their distinctive morphology (Lockley and Meyer, 2004). In the typical Lower Jurassic crocodilomorph taxon *Batrachopus* Hitchcock, 1845 (Olsen and Padian, 1986, Lockley and Meyer, 2004), the *manus* has five fingers and is usually rotated so that digit II points forwards, digit IV laterally and digit V backwards. Digit I and V are very divergent with an angle of about 180°. The crocodilian ichnogenus *Crocodylopodus* from the Early Cretaceous of Spain (Fuentes Vidarte and Meijide Calvo, 2001; Lockley and Meyer, 2004), is also characterized by five manual digit impressions with a much greater interdigital angulation and the marks of digits I and V are almost aligned. A similar feature is common in all the small fossil crocodilian footprints described up to now (Fuentes Vidarte and Meijide Calvo, 2001; Lockley and Meyer, 2004; Avanzini *et al*., 2007).

4. A possible trackmaker attribution

In 1842 the palaeontologist Richard Owen assigned the name *Rhynchosauroides articeps* to some tracks occurring in the Grinsill quarries, near Shrewsbury (UK). He based his attribution on the evidence that the tracks dimensionally corresponded to the *Rhynchosaurus* body fossils and both occurred in the same beds.

However, *Rhynchosaurus* is characterised by shorter limbs and larger digits compared to what we would expect for a *Rhynchosauroides* trackmaker (Baird, 1957). Despite of this fact, the correlation between rhynchosaurs and *Rhynchosauroides* has for a long time been accepted

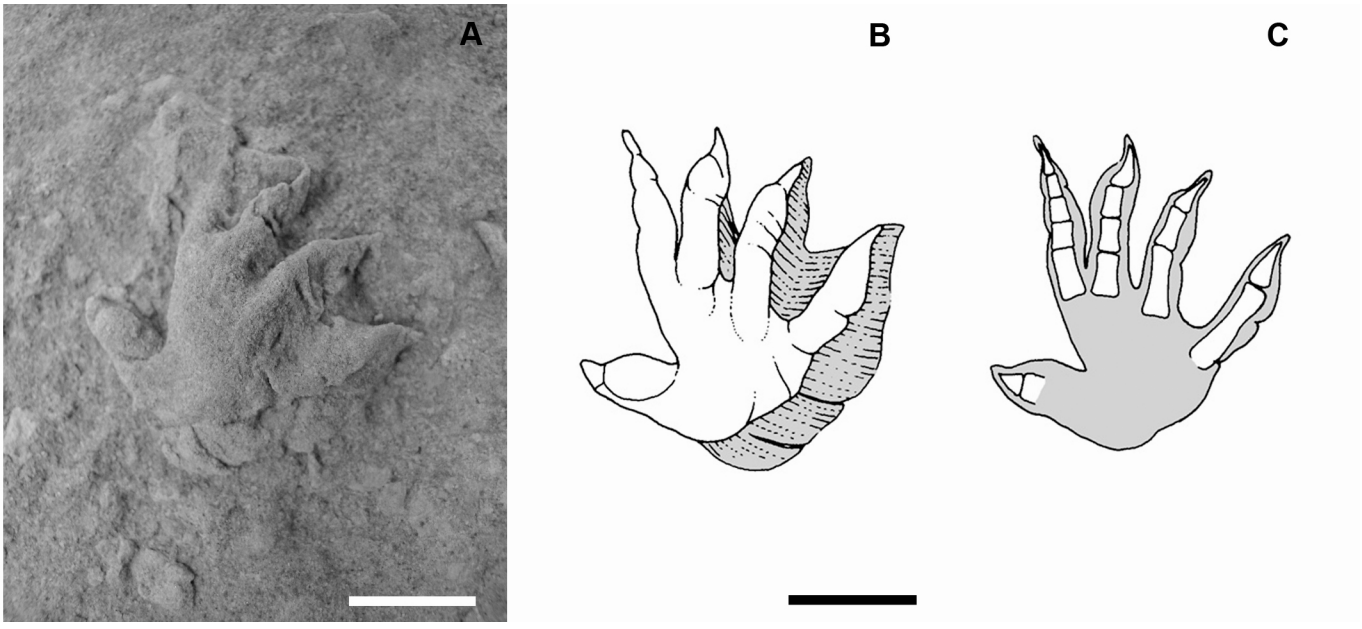

Fig. 2.- A) *Rhynchosauroides* sp. footprints from the Upper Jurassic of Asturias. The track consists of an isolated pentadactyl ectaxonic right manual print preserved as a natural cast (convex hyporelief). It is very asymmetric, plantigrade, with digits and palm deeply marked on the substrate. B) interpretative sketches with phalangeal pads, and C) skeletal phalanges restored. Scale bar: 1cm.

Fig. 2.- A) Huellas de *Rhynchosauroides* sp. del Jurásico Superior de Asturias. La traza consiste en una huella de mano aislada pentadáctila extaxónica conservada como molde natural (hiporrelieve convexo). Es muy asimétrica, plantígrada, con dedos y palma profundamente marcados en el sustrato. B) dibujos interpretativos con almohadillas en falanges y C) reconstrucción del esqueleto de las falanges. Escala 1 cm.

probably due to the abundance of rhynchosaur body fossils pertaining to Middle and Upper Triassic deposits of the southern hemisphere, in which rhynchosaurs were the dominant herbivorous.

Today there is no general agreement about *Rhynchosauroides* zoological attribution.

The structure of rhynchosaurs pes (e. g. *Noteosuchus* Watson 1912) is rather primitive and therefore not too different from that of some lepidosauromorphs or of other basal archosauromorphs (Benton 1985; Carroll 1988). Over the years trackmakers have been associated with areoscelids, nothosaurs, prolacertiforms and neodiapsids. The possibility that the *Rhynchosauroides* trackmaker may have been a "lepidosauromorph" reptile has been suggested by Haubold (1971), Lockley and Hunt (1994), Olsen and Rainforth (2003) and Domnanovich *et al*. (2008). It has also been proposed that the morphology of some *Rhynchosauroides* ichnospecies closely matches the foot structure of prolacertiform reptiles (Avanzini and Renesto, 2002, Diedrich, 2002).

It has to be pointed out, however, that the ichnogenus *Rhyncosauroides* shows a wide chronological occurrence which extends for most of the Permian and Mesozoic (Valentini *et al*., 2007). It is therefore very likely that the several ichnospecies attributed to *Rhynchosauroides* could really have been made by very different trackmakers.

Studies on Upper Jurassic lizard or lizard – like reptiles are more detailed than those on Triassic and Lower Jurassic microvertebrates (Evans, 2003 and bibliography herein).

The Lepidosauria differentiation into Squamata and Rhynchocephalia extends back into the Triassic. Squamates (lizard, snakes and amphisbaenians), with the exception of fragmentary remains from Africa and India, are only known from localities in northern continents (Laurasia). Among Squamata, only Iguania and Scleroglossa show relatively large bodies and autopodia. In the Scleroglossa group, we can exclude Gekkota and Scincomorpha, which are small lizards with a slender and graceful skeletal structure. Anguimorpha encompassing anguids, xenosaurus and the successful varanids (monitor lizards) have a more robust structure. However, all Jurassic anguimorpha are still too small when compared to this latest manus footprint, which suggests a body length of almost 30 cm.

The Rhynchocephalia had a worldwide distribution in the Late Jurassic (Evans, 1984; Gauthier *et al.,* 1988) and their relatively robust structure could be compared to this new manus footprint.

In Rhynchocephalia manus all the digits are relatively stout. Digit V is the shortest, digits IV and III are nearly equal in length wile digits II and I are shorter. The claw on the tip of the fifth digit is the longest as appears in the here described footprint.

Peabody (1948) attributed Triassic *Rhynchosauroides* to the Rhynchocephalia. Gaston *et al*. (2003) attributed *Rhynchosauroides* from Chinle Group (Upper Triassic) of the Gateway area in western Colorado to a sphenodontid/lizard-like form and Silva *et al*. (2008) also attributed *Rhynchosauroides* trackways from the Upper Triassic (Santa Maria Fm.) of Southern Brazil to lacertilian reptiles, possibly sphenodontids.

In conclusion, even though it is not possible to be certain of the Asturian footprint's trackmaker, it seems very likely that it was a rhyncocephalian reptile.

5. Conclusions

The morphofamily Rhynchosauroidea, represented by two ichnogenus (*Rhynchosauroides* and *Ganasauripus*) and nearly thirty ichnospecies, is one of the most common and geographically widespread Late Permian and Triassic ichnotaxa. The *Rhynchosauroides* ichnogenus has been reported in Europe, North America and South America. The oldest tracks are Late Permian in age and belong to the Val Gardena Sandstone in Northern Italy (Valentini *et al*., 2007) but in fact *Rhynchosauroides* is almost exclusively Triassic, where it is abundant and very common. The most recent known occurrence of *Rhynchosauroides* belongs to basal Jurassic deposits from the North American Newark Supergroup (Olsen and Rainforth, 2003); Szajna and Hartline, 2003; Rainforth, 2002; Hunt and Lucas, 2007).

The Asturian footprint appears to represent the first reported occurrence for the Late Jurassic (Lockley, 2002), and therefore, the most recent example of the ichnogenus discovered so far.

Acknowledgements

We are indebted to Jean-Michel Mazin (Université Lyon, France), Angela Delgado Buscalioni (Universidad Autónoma de Madrid) and to an anonymous referee for the formal and constructive reviews. Financial support was provided by the Government of Principado de Asturias, the University of Oviedo (Protocolo CN-04-226), the Spanish Government (Ministry of Science and Innovation, Project CGL2007-62469 /BTE) and the Museo Tridentino di Scienze Naturali.

References

Avanzini M., Renesto S. (2002): A review of *Rhynchosauroides tyrolicus* Abel, 1926 ichnospecies (Middle Triassic: Anisian-Ladinian) and some inferences on Rhynchosauroides trackmaker. *Rivista Italiana di Paleontologia e Stratigrafia*, 108 (1): 51-66.

Avanzini, M., García-Ramos, J. C., Lires, J., Menegon, M., Piñuela, L., Fernández, L. A. (2005): Turtle tracks from the Late Jurassic of Asturias, Spain. *Acta Paleontologica Polonica,* 50 (4): 743-755.

Avanzini, M., García-Ramos, J.C, Lires, J., Piñuela, L., Lockley, M.G. (2007): Crocodylomorph tracks from the Late Jurassic of Asturias (Spain). *Ichnos*, 14: 143-153.

Baird, D. (1957): Triassic reptilian footprint faunules from Milford, New Jersey. *Bulletin of the Museum of Comparative Zoology*, 117: 449-520.

Benton, M.J. (1985): Classification and phylogeny of the diapsid reptiles. *Zoological Journal of the Linnean Society*, 84: 97-164.

Carroll, R. L. (1988): *Vertebrate paleontology and evolution*.– W. H. Freeman and company, New York: 698 p.

Diedrich, C. (2002): Vertebrate track bed stratigraphy at new megatrack sites in the Upper Wellenkalk member and *orbicularis* member (Muschelkalk, Middle Triassic) in carbonate tidal flat environments of the western Germanic Basin. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 183: 185-208.

Domnanovich, N. S., Tomassini, R., Manera De Bianco, T. Dalponte, M. (2008): Nuevos aportes al conocimiento de la icnofauna de tetrápodos del Triásico Superior de Los Menucos (Complejo Los Menucos), provincia de Río Negro, Argentina. *Ameghiniana*, 45(1): 211-224.

Evans, S. (1984): The classification of the Lepidosauria. *Zoological Journal of the Linnean Society,* 82: 87–100.

Evans, S.E. (2003): At the feet of the dinosaurs: the origin, evolution and early diversification of squamate reptiles (Lepidosauria: Diapsida). *Biological Reviews*, 78 (4): 513-551.

Fuentes Vidarte, C., Meijide Calvo, M. (2001): Primeras huellas de cocodrilo en el Weald de Cameros (Soria, España). Nueva familia: Crocodylopodidae, nuevo icnogénero: *Crocodylopodus*, nueva icnoespecie: *C. meijidei.* Actas de las I Jornadas Internacionales sobre Paleontología de Dinosaurios y su Entorno, Colectivo Arqueológico-Paleontológico de Salas, C. A. S. Salas de los Infantes (Burgos, España): 329–335.

García-Ramos J.C, Lires J., Pinuela L. (2002): *Dinosaurios: Rutas por el Jurásico de Asturias*. La Voz de Asturias, Grupo Zeta, Lugones (Siero): 204 p.

García-Ramos, J.C., Piñuela, L., Lires, J. (2006): *Atlas del Jurásico de Asturias*. Ediciones Nóbel, Oviedo: 225 p.

Gaston, R., Lockley, M. G., Lucas, S. G., Hunt, A. P. (2003): *Grallator*-dominated fossil footprint assemblages and associated enigmatic footprints form the Chinle Group (Upper Triassic), Gateway area, Colorado. *Ichnos*, 10 (2-4), 153-163.

Gauthier J., Estes, R., K. de Queiroz. (1988): A phylogenetic analysis of Lepidosauromorpha. In: R. Estes and G. Pregill (eds.) *Phylogenetic relationships of the lizard families*. Stanford University Press, Stanford: 15-98.

Haubold H., (1971): Ichnia amphibiorum et reptiliorum fossilium. In: O., Kuhn (ed.), *Handbuch der Paläoherpetologie*, part. 18, Gustav Fischer Verlag, Stuttgart, Germany y Portland, USA: 121 p.

Hitchcock, E. (1845): An attempt to name, classify, and describe the animals that made the fossil footmarks of New England. *Proceedings of the American Association Geologists and Naturalists,* 6: 23-5.

Hunt, A.P., Lucas, S.G. (2007): Tetrapod ichnofacies: A new paradigm. *Ichnos*, 14: 59-68.

Irmis, R. B. (2005): A review of the vertebrate fauna of the Lower Jurassic Navajo Sandstone in Arizona. *Mesa Southwest Museum Bulletin*, 11:55-71.

Lockley M.G. (1991): *Tracking dinosaurs*. *A new look at an ancient world*. Cambridge University Press, Cambridge: 238 p.

Lockley M.G. (2002): Dinosaurios: rutas por el Jurasico de Asturias, book review. *Ichnos*, 9: 125-127.

Lockley, M. G., Hunt, A. P. (1994): A review of Mesozoic vertebrate ichnofaunas of the western interior United States: Evidence and implications of a superior tracks record. In: M. V. Caputo *et al*. (eds.), *Mesozoic Systems of the Rocky Mountain region, USA*. SEPM, Denver, Colorado: 95-108.

Lockley M.G., Hunt A. (1995): *Dinosaur tracks and other fossil footprints of the western United States*. Columbia University Press, New York: 338 p.

Lockley M.G., Meyer, Ch. (2004): Crocodylomorph trackways from the Jurassic to Early Cretaceous of North America and Europe: Implications for ichnotaxonomy. *Ichnos*, 11 (1-2): 167-178.

Maidwell, F. (1911): Notes on footprints from the Keuper of Runcorn Hill. *Liverpool Geological Society,* 11: 140-152

Olsen, P.E., Padian, K. (1986): Earliest records of *Batrachopus* from the southwestern United States, and a revision of some Early Mesozoic crocodylomorph ichnogenera. In: K. Padian (ed.). *The Beginning of the Age of Dinosaurs*. Cambridge University Press, Cambridge.: 260-273.

Olsen, P.E., Rainforth. E.C. (2003): The "Age of Dinosaurs" in the Newark basin, with special reference to the lower Hudson Valley. In: A.E. Gates, P.E. Olsen, (eds.), *Geology of the Lower Hudson Valley.* Field Trip Guide Book, New York State Museum, Albany, 73:59-176.

Owen, R. (1842): Report on British fossil reptiles, part II. *Report of the British Association for the Advancement of Science*, 11: 60-204

Peabody, F.E. (1948): Reptile and amphibian trackways from the Lower Triassic Moenkopi Formation of Arizona and Utah. *Bulletin of the Departament of Gelogical Science University of California Publications*, 27: 295-467.

Rainforth, E.C. (1997): *Vertebrate ichnological diversity and census studies, Lower Jurassic Navajo Sandstone*. Unpublished MS report, University of Colorado at Boulder, Department of Geological Sciences: 20 p.

Rainforth, E.C. (2002): Tails of saurischian dinosaurs in the Early Jurassic of the Newark Supergroup (eastern North America). *Geological Society of America, Abstracts with Programs*, 34 (1): 61.

Silva, R. C., Ferigolo, J., Carvalho, I.S., Fernandes, A. C. S. (2008): Lacertoid footprints from the Upper Triassic (Santa Maria Formacion) of Sourthern Brazil. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 262: 140-156.

Szajna, M. J., Hartline, B. W. (2003): A new vertebrate footprint locality from the Late Triassic Passaic Formation near Birdsboro, Pennsylvania. In: P. M. LeTourneau, P. E. Olsen (eds.). *The Great Rift Valleys of Pangea in Eastern North America, Volume 2: Sedimentology, Stratigraphy, and Paleontology.* Columbia University Press, New York: 264-272

Valentini, M, Conti, M. A., Mariotti, N. (2007): Lacertoid footprints of the Upper Permian Arenaria di Val Gardena Formation (Northern Italy). *Ichnos*, 14: 193-218.

Watson, D. M. S. (1912): *Eosuchus colletti*, gen. et spec. nov. *Records of the Albany Museum*, 2: 298-299.